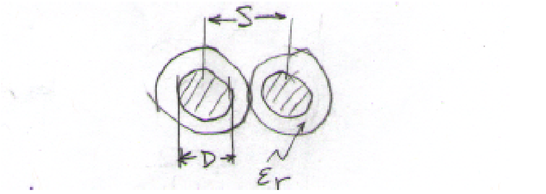
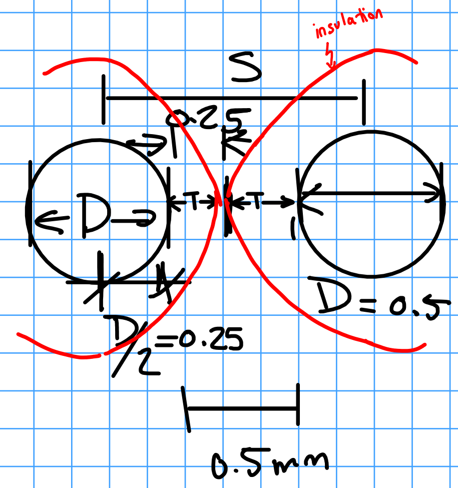


is:

$$Z_0 \approx \frac{120}{\sqrt{\varepsilon_r}} \ln\left(\frac{2S}{D}\right)$$

Exercise 1: What is the characteristic impedance of UTP made from 24-gauge wire with polyethylene insulation ($\varepsilon_r = 2.2$) of 0.25mm thickness?

$D = 0.5_{mm}$ (24ga)



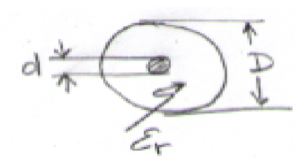
$S = 1mm \left(\frac{D}{2} + T + T + \frac{D}{2} = 0.25 + 0.25 + 0.25 + 0.25\right)$

$D = 0.5$

$$Z_0 = \frac{120}{\sqrt{2.2}} \ln\left(\frac{2 \cdot 1}{0.5}\right) \approx \frac{100}{1} \ln(4)$$

$\approx 100 \times 2 = 200$

(116 Ω)



is:

$$Z_0 \approx \frac{138}{\sqrt{\varepsilon_r}} \log_{10}\left(\frac{D}{d}\right)$$

Exercise 2: What is the characteristic impedance of a co-ax cable with a 0.8mm diameter center conductor, 3.5mm

$d = 0.8$ mm

$D = 3.5$mm

$\varepsilon_r = 1.5$

$$Z_0 = \frac{138}{\sqrt{1.5}} \log_{10}\left(\frac{3.5}{0.8}\right)$$

$\approx 100 \log_{10}(4)$

$\approx 100 \cdot \frac{1}{2} = 50\ \Omega$

actually $72\ \Omega$

$$Z_O = \sqrt{\frac{L}{C}}$$

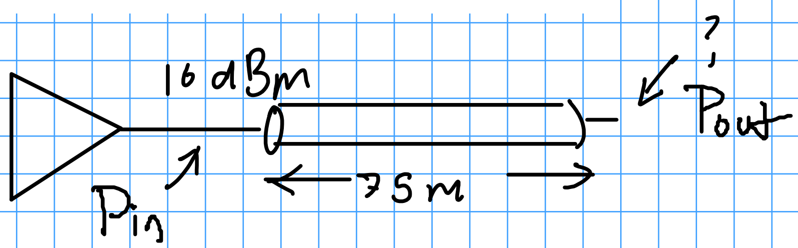
Exercise 3: What is the characteristic impedance of a lossless cable with an inductance of 94 nH per foot and capacitance of 17pF/ft?

$$Z_o = \sqrt{\frac{94 \times 10^{-9}}{17 \times 10^{-12}}} \approx \sqrt{\frac{100}{20} \times 10^{3}}$$

$$\approx \sqrt{5000} \approx 75\,\Omega$$

Exercise 4: An 800 MHz signal is output from a CATV amplifier at a power level of 10dBm. What power level would you expect at the other end of a 75m run of co-ax whose loss is specified as 24dB/100m at 800 MHz?

Loss = 24 dB/100m



$$\text{loss} \quad \frac{75}{100} \times 24 = \frac{3}{4} 24 = 18\ \text{dB}$$

$$P_{out} = P_{in} - \text{Loss (dB)}$$

$$= 10\ \text{dBm} - 18 = -8\ \text{dBm}$$

dBV = dB relative to 1 V $= 20 \log\left(\frac{V}{1V}\right)$

dBm = dB " " 1 mW $= 10 \log\left(\frac{P}{1mW}\right)$

dBW

dBmW

e.g. What is 4V in dBV?

$$20 \log\left(\frac{4}{1}\right) = 12 \text{ dBV}$$

what is 100mW in dBm?

$$10 \log\left(\frac{100}{1}\right) = 20 \text{ dBm}$$

$$VF = \frac{1}{\sqrt{\varepsilon_r}}$$

Exercise 5: What is the velocity factor for a cable with polyethylene insulation ($\varepsilon_r = 2.2$)? How long would it take for a signal to propagate 100m? For a cable with air dielectric?

$$v = \frac{d}{t}$$

$$t = \frac{d}{v}$$

$$VF = \frac{1}{\sqrt{2.2}} \approx 0.7$$

$$\text{velocity} = 0.7 \times 3\times10^8 \approx 2\times10^8 \text{ m/s}$$

$$\text{prop. time} = \frac{d}{v} = \frac{100\text{m}}{2\times10^8 \text{ m/s}} = 50\times10^{-8} = 500\text{ns}$$

if $\varepsilon_r = 1$ (air) $VF = 1$

$$\text{prop. time} = \frac{100\text{ m}}{3\times10^8} = 330\text{ ns.}$$

Exercise 6: If the optical signal wavelength is 1330nm what is the frequency?

$$\lambda = 1330\times10^{-9}\text{ m}$$

$$c = 3\times10^8 \text{ m/s (free space)}$$

$$\overset{?}{=} 2\times10^8 \text{ m/s (for this fiber?)} = \frac{1}{\sqrt{\varepsilon_r}}$$

$$f = \frac{c}{\lambda} = \frac{2\times10^8}{1.3\times10^{-6}} \approx 1.7\times10^{14}$$

Exercise 7: How much does a cable's resistance increase when the gauge size increases by 6? By 3? Hint: a wire's resistance is ^inversely proportional to its cross-sectional area.

increase of 6 → reduces diameter by 2

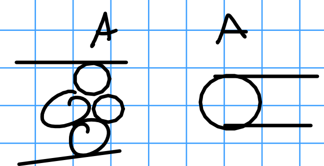
cross-sectional area decreases by 4 (2^2)

($A = \pi r^2$)

resistance $\propto \frac{1}{A}$ ∴ resistance also decreases by 4X

increase gauge by 3 → diameter decreases by $\sqrt{2}$

resistance decreases by 2X



$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

Where P_R and P_T are the received and transmitted powers, G_T and G_R are the gains of the transmit and receive antennas, λ is the wavelength and d is the distance from transmitter to receiver.

Exercise 8: A point-to-point link uses a transmit power of 1 Watt, transmit and receive antennas with gains of 20dB and operates at 3 GHz. How much power is received by the receiver?

$d = \frac{10^3}{4\pi}$

dBm = 10 log (P in mW)

$P_T = 1W = 1000mW$ $\quad 10^3 mW = 30$ dBm

G_T G_R = 20 dB

$\lambda = \frac{c}{f} = \frac{3\times10^8}{3\times10^9} = 0.1m.$

$d = \frac{10^3}{4\pi}$ $\qquad \left(\frac{\lambda}{4\pi d}\right)^2 = \left(\frac{0.1}{4\pi \cdot \frac{10^3}{4\pi}}\right)^2 = 10^{-8}$

$10\log(10^{-8}) = 10 \cdot -8 = -80$ dB.

$P_R\,(dB) = \underbrace{P_T + G_T + G_R + 10\log\left(\frac{\lambda}{4\pi d}\right)^2}_{\text{in dB}}$

$= 30 + 20 + 20 + -80$ (dBm)

$= -10$ dBm